

PHOTODISINTEGRATION OF SILVER AND ALUMINUM BY TWENTY MEV X-RAYS

BY

BENJAMIN CLINTON DIVEN

A.B., University of California, 1941

M.S., University of Illinois, 1948

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYSICS
IN THE GRADUATE COLLEGE OF THE
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Energy and angular distributions of photoprotons from silver and aluminum have been determined. The silver and aluminum foils were irradiated in a collimated beam of x-rays from the 22 Mev betatron at the University of Illinois. Protons from a foil were caught in two nuclear photographic emulsions at near grazing incidence and at angles of 20° to 160° from the x-ray beam. The energy and angular distributions of the photoprotons were studied and in the case of silver the ratio of the number of protons emitted to the number of neutrons emitted was determined. The energy distributions are compared to calculations based on several level density formulas. The computed energy distributions of photoprotons are given by

$$F(\epsilon_p) = \epsilon_p \sigma_p \int_{B_p + \epsilon_p}^{E_{\max}} [\sigma(\gamma, n) N_{\omega_p} / \int_0^{E_{\max} - B_n} \epsilon_n \sigma_n \omega_n d\epsilon_n] dE$$

where σ_p is the reaction cross section for protons of energy ϵ_p incident on the residual nucleus and σ_n is the corresponding cross section for neutrons.

$\sigma(\gamma, n)$ is the (γ, n) cross section.

N is the number of quanta per cm^2 per unit energy interval in the x-ray beam.

ω is the level density in the residual nucleus at the excitation energy which results after emission of a proton of energy ϵ_p or neutron of energy ϵ_n .

B_p , B_n are thresholds for the (γ, p) and (γ, n) reactions, respectively.

$E_{\max}$ is the maximum x-ray energy for the spectrum used.

In order to determine the variation with energy of the

(γ, n) cross section, a separate experiment was performed. Samples of silver and aluminum were irradiated in the beta-tron beam at various maximum x-ray energies and the activity produced by (γ, n) reactions was determined at each energy. From these activation curves and the theoretical x-ray spectrum, the energy dependence of the (γ, n) cross section is deduced. The cross section for silver shows a maximum at 16 or 17 Mev. The aluminum cross section has no maximum up to 20 Mev.

The proton spectrum from silver irradiated with 20.8 Mev maximum energy x-rays is in reasonable agreement with the statistical theory for proton energies up to 8 or 10 Mev. There are relatively more protons observed with energy from 10 to 13 Mev than predicted by the statistical theory. It is probably significant that the angular distribution of protons with energies below 10 Mev is spherically symmetrical while protons of energy greater than 10 Mev are emitted preferentially near 90° to the x-ray beam.

The proton spectrum from aluminum irradiated with 20.8 Mev. x-rays is compatible with the statistical theory if one assumes a level density for the residual nucleus which increases slowly with excitation energy. The angular distribution of photoprotons from aluminum is spherically symmetrical within experimental error.

Various cross sections and other constants obtained incidental to this work are tabulated below.

Ag^{109}

$\sigma (\gamma, n)$ PEAK VALUE	$\sigma (\gamma, n)$ 17.5 MEV	$\int \sigma dE$ OVER RESONANCE
$3.2 \times 10^{-25} \text{cm}^2$	$1.7 \times 10^{-25} \text{cm}^2$	1.6 Mev barns

Al^{27}

Mean (γ, p) cross section 12 to 20.8 Mev:
 $6 \times 10^{-27} \text{cm}^2$

Threshold for (γ, p) reaction:
 $8.5 \pm 0.5 \text{ Mev}$

Silver

Ratio of numbers of protons to neutrons emitted when irradiated with 20.8 Mev maximum energy x-rays as observed and computed with several level density formulas:

Observed	$\omega = \exp (aE)^{1/2}$	$\omega = \exp (aE)^{1/2}$	$\omega = \ln [(E + b)/b]$
	$a = A/5 \text{ Mev}^{-1}$	$a = 1.6 (A - 40)^{1/2} \text{ Mev}^{-1}$	$b = 20/A \text{ Mev}$
$.023 \pm .008$	.022	.038	.128

VITA

Benjamin Clinton Diven was born January 5, 1919, in Chico, California. He attended Chico State College and the University of California, receiving the Bachelor of Arts degree from the latter institution in May, 1941. He began graduate work there at that time. From March, 1943 to January, 1946 he was a staff member of the University of California Los Alamos Scientific Laboratory. In January, 1946 he entered the Graduate College of the University of Illinois and held a Research Assistantship from that time until July, 1949. During the academic year 1949-50 he has held an Atomic Energy Commission Predoctoral Fellowship.



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